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# Description

# *CENTER LOCATED CUTTER TEETH ON SHROUDED TURBINE BLADES*

## BACKGROUND OF INVENTION

[0001] The present invention relates generally to turbines and turbine blades and more particularly relates to tip shrouded turbine blades with center located cutter teeth.

[0002] A turbine assembly, such as that used in power generation, typically generates rotating shaft power by expanding hot compressed gas produced by combustion of a fuel. Gas turbine buckets or blades generally have an airfoil shape designed to convert the thermal and kinetic energy of the flow path gases into mechanical rotation of the rotor.

[0003] Turbine performance and efficiency may be enhanced by providing a seal at the tip of the bucket to block the flow of air over or around the top of the bucket that would otherwise bypass the bucket. For example, a tip shroud may be positioned on the end of the bucket opposite the

end attached to the rotating shaft. The tip shroud generally includes a shelf and a sealing rail. This configuration reduces spillover by decreasing the size of the clearance gap and by interrupting the hot gas path around the end of the bucket. In addition, the sealing rail may have one or more cutter teeth thereon. The cutter teeth may further restrict spillover by cutting through a honeycomb-like structure that may surround the tip shroud.

[0004] Tip shrouds, however, are subject to creep damage due to the combination of high temperatures and centrifugally induce bending stresses. The failure of a single bucket or blade may cause the entire turbine to be taken offline. In addition to the downtime, such a repair of a bucket is time consuming and/or expensive.

[0005] There is a desire, therefore, for a turbine blade shroud with improved ability to handle temperature and stress. Such a turbine blade shroud should provide increased lifetime while also increasing the efficiency of the turbine system as whole.

## SUMMARY OF INVENTION

[0006] The present invention thus provides a tip shroud for use with a bucket of a turbine. The tip shroud may include a seal rail with a middle portion and a cutter tooth mounted

about the middle portion of the seal rail.

[0007] The cutter tooth may include a top portion and a base portion. The cutter tooth also may include a built-up area adjacent to the base portion. The cutter tooth may include a first cutter tooth and a second cutter tooth. The first cutter tooth and the second cutter tooth may include an offset position about the middle portion of the seal rail. The first cutter tooth may be positioned about 2.15 to about 2.2 inches (about 63.5 to about 55.9 millimeters) from a first end of the seal rail while the second tooth may be about 2.13 to about 2.18 inches (about 54.1 to about 55.37 millimeters) from the first end.

[0008] The seal rail may include a length of about 4.0 to about 4.25 inches (about 101.6 to about 107.9 millimeters). The first top portion and the second top portion may include a height from point "C" of about 0.52 to about 0.54 inches (about 13.21 to about 13.72 millimeters). The first top portion and the second top portion may include a width of about 0.10 to about 0.13 inches (about 2.54 to about 3.3 millimeters).

[0009] The first base portion of the first cutter tooth may extend in a direction perpendicular to the seal rail of about 0.56 to about 0.58 inches (about 14.22 to about 14.73 mil-

limeters) while the second base portion of the second cutter tooth may extend about 0.45 to about 0.47 inches (about 11.43 to about 11.99 millimeters). The first base portion and the second base portion may include a width along the direction of the seal rail from about 0.5 to about 0.52 inches (about 12.7 to about 13.21 millimeters) to about 0.3 to about 0.32 inches (about 7.62 to about 8.19 millimeters).

[0010] A further embodiment of the present invention may provide a tip shroud for use with a bucket of a turbine. The tip shroud may include a seal rail with a middle portion, a first cutter tooth mounted on the seal rail about the middle portion, and a second cutter tooth mounted on the seal rail about the middle portion. The first cutter tooth and the second cutter tooth may be offset along the middle portion on the seal rail. The first cutter tooth may be positioned about 2.15 to about 2.20 inches (about 54.61 to about 56.39 millimeters) from a first end of the seal rail while the second tooth may be about 2.13 to about 2.18 inches (about 54.1 to about 55.37 millimeters) from the first end.

[0011] A further embodiment of the present invention may provide a tip shroud for use with a bucket of a turbine. The

tip shroud may include a seal rail with a first cutter tooth and a second cutter tooth mounted thereon about a middle portion thereof. The first cutter tooth may include a first base with a first length and the second cutter tooth may include a second base with a second length. The first length may exceed the second length.

[0012] These and other features of the present invention will become apparent upon review of the following detailed description when taken in conjunction with the drawings and the appended claims.

## Brief Description of Drawings

[0013] Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:Fig. 1 is a side view of a known turbine bucket having a tip shroud.

[0014] Fig. 2 is a top plan view of a known tip shroud with a cutter tooth on the leading edge.

[0015] Fig. 3 is a top plan view of a tip shroud of the present invention showing a center mounted cutter tooth.

[0016] Fig. 4 is a top plan view of the tip shroud of Fig. 3 with the bucket or airfoil shown in phantom lines.

[0017] Fig. 5 is a side cross-sectional view of the cutter tooth of

Fig. 4.

[0018] Fig. 6 is a top plan view of an alternative embodiment of the tip shroud of the present invention showing a center mounted cutter tooth

## DETAILED DESCRIPTION

[0019] Referring now to the drawings, in which like numbers refer to like elements throughout the several views, Fig. 1 shows a typical tip shrouded turbine bucket *10*. The turbine bucket *10* includes an airfoil *12*. The airfoil *12* is the active component that intercepts the flow of gases and acts as a windmill vain to convert the energy of the gases into tangential motion. This motion in turn rotates the rotor to which the buckets *10* are attached.

[0020] A tip shroud *14* may be positioned at the top of the airfoil *12*. The tip shroud *14* essentially is a flat plate supported towards its center by the airfoil *12*. Positioned along the top of the tip shroud *14* may be a seal rail *16*. The seal rail *16*, as described above, prevents the passage of flow path gases through the gap between the tip shroud *14* and the inner surface of the surrounding components.

[0021] Fig. 2 shows the use of one or more known cutter teeth *18* on the seal rail *16*. The cutter tooth *18* is positioned on the leading edge of the tip shroud *14*. The use of the cutter

teeth *18* may further reduce spillover by clearing a path through the honeycomb of the shroud that may be used for seal stability. The use of this leading edge position, however, may stress the tip shroud *14*, particularly under high turbine temperatures.

[0022] Figs. 3–5 show the improved turbine bucket *100* of the present invention. As above, the turbine bucket *100* includes the airfoil *110* (shown in phantom lines in Fig. 4.) The airfoil *110* ends in the tip shroud *120*. The tip shroud *120* may be of conventional design. Positioned on top of the tip shroud may be a seal rail *130*. The seal rail *130* may extend about the length of the tip shroud *120*.

[0023] Positioned on the seal rail *130* may be one or more cutter teeth *140*. In this example, the cutter teeth *140* are positioned about the center of the seal rail *130*. A first cutter tooth *150* and a second cutter tooth *160* are shown. This location may extend the life of the turbine bucket *100* by decreasing the stress present in the fillet below the tip shroud *120*. This location also provides a more symmetrical design to the tip shroud *120* as a whole.

[0024] Each cutter tooth *140* may have a top portion *170* that extends into a base portion *180*. If the seal rail *130* is about 4.0 to about 4.25 inches long (about 101.6 to about

107.95 millimeters), the top portion *170* may have a length of about 0.329 inches (about 0.86 millimeters) and a width of about 0.1 to about 0.13 inches (about 2.54 to about 3.30 millimeters). The top portion *170* may have a height of about 0.52 to about 0.54 inches (about 13.21 to about 13.72 millimeters) from point "C".

[0025] The first tooth *150* and the second tooth *160* may be offset somewhat so as to accommodate the overall shape of the tip shroud *120*. As is shown in Fig. 5, the top *170* of the first tooth *150* and the second tooth *160* may be offset along a centerline *T* of the tip shroud *120* and the seal rail *130*. As such, the top *170* of the first tooth *150* may be about 2.15 to about 2.2 inches (about 54.6 to about 55.88 millimeters) from one end of the seal rail *130* located at point "P"while the top *170* of the second tooth *160* may be about 2.13 to about 2.18 inches (about 54.1 to about 55.32 millimeters) from that end located at point "P".

[0026] The base portion *180* of the first cutter tooth *150* may extend in a direction perpendicular to the seal rail *130* of about 0.56 to about 0.58 inches (about 14.22 to about 14.73 millimeters) while the base portion *180* of the second cutter tooth *160* may only extend about 0.45 to about

0.47 inches (about 11.43 to about 11.99 millimeters). The base portion *180* of both cutter teeth *150*, *160* may have a width (along the direction of the seal rail *130* that extends from about 0.5 to about 0.52 inches (about 12.7 to about 13.21 millimeters) to about 0.30 to about 0.32 inches (about 7.62 to about 8.13 millimeters) near the top portion *170*.

[0027] This configuration may be used OLE_LINK1for the second stage bucket of a "9FA+e"turbine sold by the General Electric Company of Schenectady, New YorkOLE_LINK1. The configuration provides a tip shroud *120* with a more symmetrical design so as to reduce the stress on the tip shroud *120* as a whole and the fillet below the shroud *120*, if one is present. The configuration also should increase the overall lifetime of the various parts.

[0028] Fig. 6 shows a similar design, in this case a turbine bucket *200* for the second stage bucket of a "7FA+e"turbine sold by the General Electric Company of Schenectady, New York. The turbine bucket *200* may have an airfoil *210* with a tip shroud *220* and a seal rail *230*. The tip shroud *220* may have somewhat different dimensions from those described above with the tip shroud *120*.

[0029] Positioned on the seal rail *230* may be the cutter teeth *240*,

with a first cutter tooth *250* and a second cutter tooth *260*. The cutter teeth *240* also may have a top portion *270* that meets along the seal rail *230* and a base *280*. The base *280* may further include a built up area *290*. The built up area *290* may provide for attachment of the cutter teeth *240* to the tip shroud *220*. The cutter teeth *240* may be attached to the seal rail *230* and the tip shroud *220* by a welding of other types of conventional joinder methods.

[0030] In this case, if the seal rail *230* is about 4.0 to about 4.25 inches long (about 101.6 to about 107.95 millimeters), the top portion *270* may be about 0.52 to about 0.54 inches (about 13.21 to about 13.72 millimeters) in height and about 0.10 to about 0.13 inches (about 2.54 to about 3.3 millimeters) in width. The first tooth *250* and the second tooth *260* also may be offset somewhat. As such, the top *270* of the first tooth *250* may be about 2.15 to about 2.20 inches (about 54.61 to about 55.88 millimeters) from one end of the seal rail *230* while the top *270* of the second tooth *260* may be about 2.13 to about 2.18 inches (about 54.10 to about 55.37 millimeters) from that end.

[0031] The base portion *280* of the first cutter tooth *250* may extend in a direction perpendicular to the seal rail *230* by about 0.56 to about 0.580 inches (about 14.22 to about

14.73 millimeters) while the base portion *280* of the second cutter tooth *260* may only extend about 0.45 to about 0.47 inches (about 11.43 to about 11.99 millimeters). The base portion *280* of both cutter teeth *250*, *260* may have a width (along the direction of the seal rail *230* that extends from about 0.50 to 0.52 inches (about 12.7 to about 13.21 millimeters) to about 0.30 to about 0.32 inches (about 7.62 to about 8.19 millimeters) near the top portion *270*. The built up area *290* may have of width of about 0.6 to about 0.7 inches (about 15.24 to about 17.78 millimeters).

[0032] It should be understood that the foregoing relates only to the preferred embodiments of the present invention and that numerous changes and modifications may be made herein without departing from the general spirit and scope of the invention as defined by the following claims and the equivalents thereof.